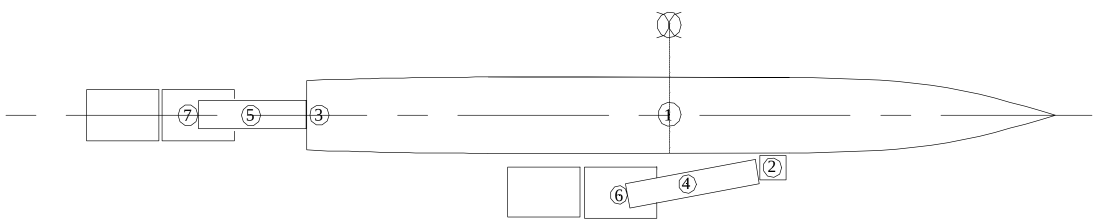
Ramp twist and pitch data, TAKR-RRDF model test.

In the model tests reported in CRDKNSWC/HD-1421-05, measurements included vertical acceleration and roll both on the ship (T-AKR 296), and on RRDF platforms at the side and stern of the ship. Measurement locations are given in Table 2 of the report and are shown in this sketch:



The table below shows RMS values for certain quantities evaluated from the model test data in sea state 3 (nominal significant height = 4.1 ft):

1. Ramp twist- this is defined as the <u>relative</u> roll motion between the ship and RRDF platform. For the side ramp this is the relative roll between the ship (#1) and the side platform (#6). For the stern ramp this is the relative roll between the ship (#1) and the stern platform (#7).
2. The relative pitch between the ramps and the ship (i.e. the hinge angle at the top of each ramp) was not directly measured. However, there were vertical accelerometers at both top and bottom of each ramp. These are locations marked #2 and #6 for the side ramp, and #3 and #7 for the stern ramp. These accelerations have been double-integrated to estimate the vertical displacement at the ends of the ramps, and the difference between displacement at the top and bottom of the ramps is the relative vertical motion given in the table. This allows an estimate of the ramp hinge angle at the top connection point, when the length of each ramp is considered.

SS 3 Stdv					
HEADING	RUN NO	SIDE RAMP TWIST	STERN RAMP TWIST	SIDE REL VERT MO	STERN REL VERT MO
		deg	deg	feet	feet
Port Qtr	106	0.29	0.54	0.26	0.67
Port Beam	91	0.47	1.18	0.51	0.23
Port Bow	137	0.30	0.49	0.40	0.72
Head Sea	72	0.23	0.15	0.49	0.32
Stbd Bow	135	0.45	0.52	0.80	0.75
Stbd Beam	70	1.92	1.14	1.20	0.23
Stbd Qtr	119	0.48	0.55	0.89	0.59

3. The worst case twist angle is for the side ramp in starboard beam waves (the side ramp and RRDF are on the starboard side of the TAKR), where the RMS angle approaches two degrees. The twist angle is caused mostly by the roll motion of the side RRDF, which is nearly double the roll of the stern RRDF due to reflection of waves off the ship in beam waves. Note that all the values in the table are RMS (standard deviation)

values. The significant amplitude of any given response will be twice the RMS, and extreme values can be expected to be in the range of 4-5 times RMS. Thus, the significant twist angle is about 4 deg, and the maximum will be 8-10 deg.

4. The worst case relative vertical motion is also for the side ramp in starboard beam waves. Since the ramp length is 165 feet, and the horizontal distance between the upper and lower ends of the ramp is 162.66 feet (see Fig. 1 of the test report), the RMS angle is estimated to be 0.42 degrees (1.2/162.66 = .00738 radians = 0.42 deg). Again, the significant and maximum values will be several times larger; the maximum hinge excursion (at the top of the ramp) will be around 2 degrees in Sea State 3. It is difficult to estimate the relative pitch between the bottom of the ramp and the RRDF. However, Table A.3 of the test report shows a peak pitch of the side RRDF of 6.28 deg in starboard quartering waves, while the peak pitch of the ramp is estimated at around 1.5 deg at this heading. If these motions are in phase, the method of attachment at the bottom of the ramp must be able to take about 8 degrees of relative pitch.
5. This analysis has concentrated on the model test results for NATO Sea State 3. However, some of the experiments were done in waves with an Ochi 6-parameter spectrum to include swell with a modal period approximating the natural roll period of the T-AKR 296 (15 seconds), and some comments are in order regarding the possible consequences for ramp twist and hinge angle. As shown in Table A.4, peak roll angles on the ship increase from about 1 degree in the NATO Sea State 3, to as much as 5.4 deg with the swell. The roll motions of the RRDF are generally less in swell conditions than for the NATO condition. This is because the total significant wave height was kept the same for both sea conditions, so that when swell is included less wave energy is available to excite the roll motion of the RRDF (which has a much shorter natural period). The net result, for ramp twist, is that the peak twist angle appears to be no worse with swell than with the NATO spectrum. However, the greatly increased roll of the ship, due to the swell, can have a significant effect on the hinge angle of the side ramp. This is because of the large lateral lever arm to the hinge point (71.3 feet according to Fig. 1 of the test report). A peak roll of 5.4 degree, combined with this lever arm, can result in a vertical displacement of 6.7 feet at the hinge. Depending on the phase of this motion component, relative to the heaving of both the ship and the RRDF, this condition may be the worst case for hinge angle at the top of the side ramp.